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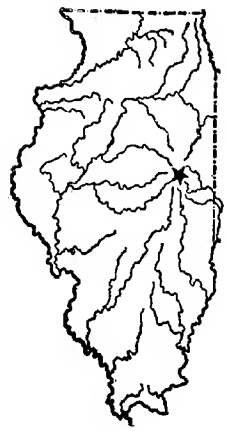
AN APPLE CANKER DUE TO CYTOSPORA

By FRANK LINCOLN STEVENS



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AN APPLE CANKER DUE TO CYTOSPORA.

By FRANK LINCOLN STEVENS, Professor of Plant Pathology, University of Illinois, in Cooperation With the Department of Horticulture

A canker on young apple trees which appears capable of doing much damage was submitted to the author for identification in the spring of 1918. Tho noted on only a few trees, its rapid and complete possession of the tree, together with the fact that it does not agree closely with other apple-tree cankers previously described, makes it worth while to give rather a complete statement of the present knowledge of it.

The apple cankers were sent by Mr. G. P. Callender, of Altona, Illinois. He stated that he had received the trees from a certain nursery company in New York, on April 27, 1918. Requests were made of the company that they send specimens of any cankers they might find in their orchards, but no reply was received.

DESCRIPTION OF THE CANKER

One specimen was found on the main trunk of a young tree about 2 cm. in diameter. The canker extended a total length of 22 cm., completely encircling the tree thruout most of that distance, altho it extended 2 or 3 cm. farther up and down on one side of the tree than on the other side.

There was no abrasion or wound which seemed to mark the place of the original infection. Altho several lateral branches had been cut off from the portion found cankered, the wounds were in all cases nicely healing over with callous. The canker for the most part was of a tan color, similar to that which is frequently exhibited in young cankers of apple blotch. Portions of the canker, toward one end, were of much darker bronzed or purplish color, altho at the other end of the canker this color was absent.

The demarcation between the diseased and the healthy tissues was very sharp with a slight breaking away of the diseased from the healthy tissues. On removing the bark, a black transverse line about 1 mm. wide was disclosed, apparently separating the healthy from the diseased tissues. It is quite probable that the canker at this point was in dormant condition, resting, not progressive. The other end of the canker did not show sharp limitations between the diseased and the healthy tissues, which gradually faded, one into the other, and did not show externally the 2-cm., dark, purplish band mentioned above, adjacent to this end of the canker.

The canker was studded thruout its area with black pustules having the appearance of pycnidia or perithecia. These were slightly raised conically above the surrounding surface, were black, about 1 to 2 mm. in diameter, and were so abundant that an unbroken area of 5 square millimeters could scarcely be found. A color photograph of this twig was made June 5.

THE FUNGUS

The fungus is apparent to the eye, externally, as small black pustules under, or crumpent thru, the cuticle. On microscopic examination these prove to be relatively large compound pycnidia made up of numerous irregularly arranged cavities in a mass of dense stromatic structure. Views of the pycnidia from various sections are shown in Figs. 1 to 11.

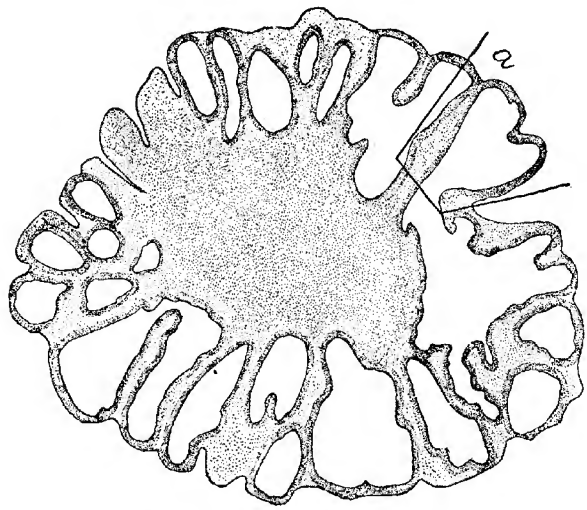
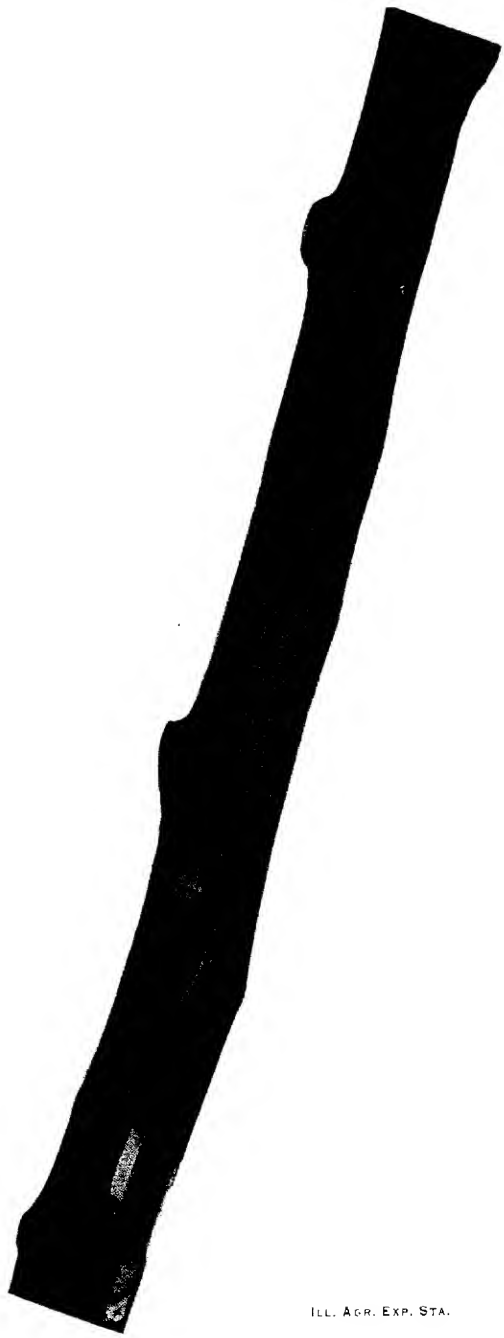


FIG. 1.—CROSS-SECTION OF A PYCNIDIUM

Fig. 1 shows a cross-section, i.e., a section in a plane parallel to the base of a pycnidium, which represents the condition most frequently found. There is a large number of locules, irregular in size and shape, but arranged in a circular manner around a sterile area, with their longer axes along the radii. Another pycnidium is shown in similar view in Fig. 2, and a section in the same direction but farther from the base, in Fig. 3. Fig. 4 is drawn from a section longitudinal to the twig and parallel to the plane of the radius of the twig, therefore cutting from the top of the pycnidium to its base. The irregular locules are here shown, and the large



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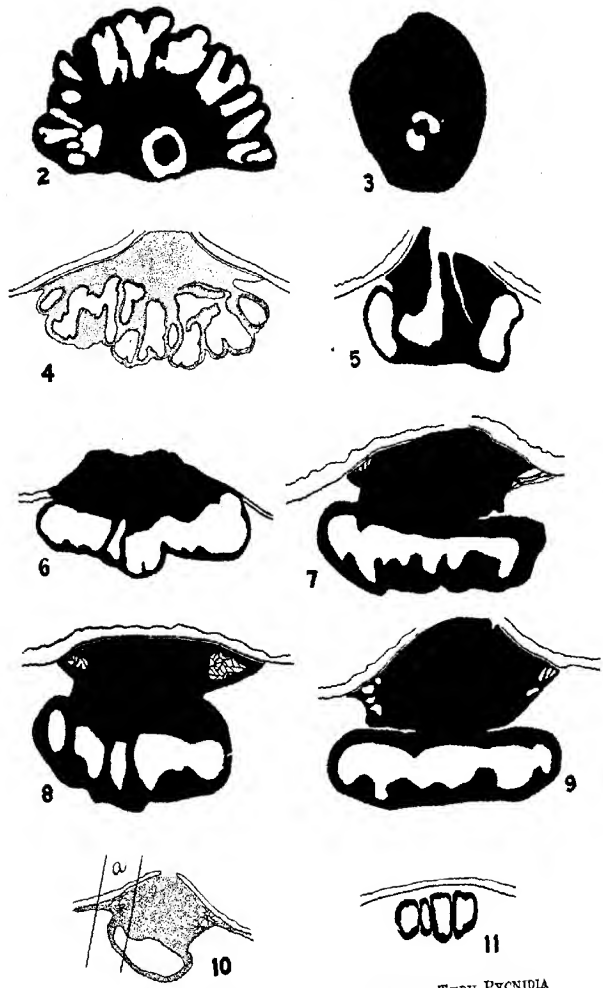

FIGS. 2-11.—CROSS AND VERTICAL SECTIONS THRU PYCNIDIA

covering mass of sterile mycelium, all below the cuticle but breaking thru it.

Figs. 5 to 10 give similar views showing considerable variation as to the locules and their openings into the ostiole, but a general agreement in that the sporiferous cavities are covered in all cases by a dense stromatic or clypeate structure. (Ectostroma, cf. Ruhland.[32]) Fig. 11 shows a similar section, but nearly tangential to the edge of a pycnidium. Fig. 12 shows the detail of the portion of the pycnidium marked "a" in Fig. 1. The interlocular material is seen to be a firm pseudoparenchyma, the walls of the outer cells being somewhat thicker than the walls of the inner cells. The entire inner surface of the locules is lined with a close palisade of conidiophores, which are in the main simple and narrow, and about 17 to 20 μ long by .5 to .7 μ thick, tho in some instances they may branch, as figured by Aderhold.[10] This conidiophore layer is shown still more clearly in Fig. 13. Fig. 14 shows the detail of the part marked "a" in Fig. 10. It is seen that in certain parts the fungus mycelium is loosely woven and with open interstices. Fig. 15 shows the spores, which are produced in very great number. They are

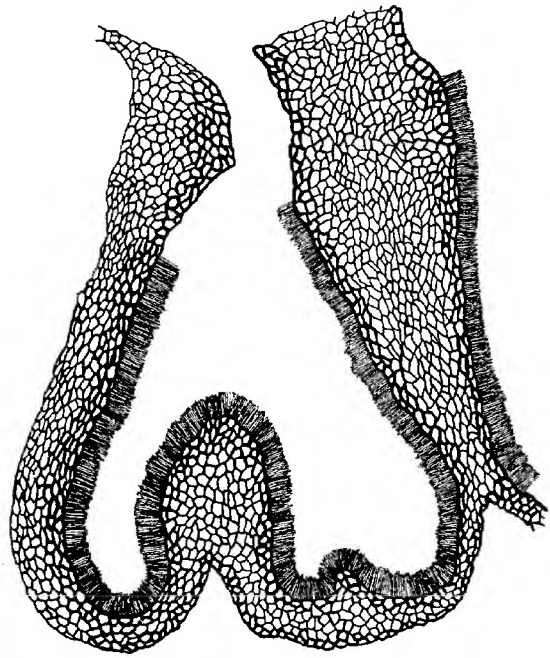

FIG. 12.—DETAIL OF PORTION OF PYCNIDIUM MARKED "A" IN FIG. 1

hyaline, 1-celled, obtuse, quite uniform in size (7x1.6 μ), and either straight or slightly curved.

The mycelium is thin and hyaline and by these two characteristics is easily distinguished from the mycelium of the black-rot fungus. Close search revealed no ascigerous structures.

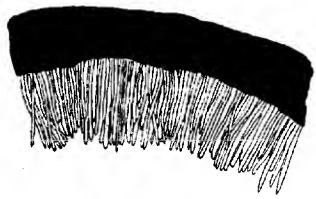

FIG. 13.—PORTION OF A CONIDIOPHORE LAYER

ISOLATIONS

The fungus was easily secured in pure culture. Fragments from the interior of a pycnidium were placed in a drop of sterile water and portions of this drop then transferred to tubes of melted corn-meal agar and poured into Petri dishes. Thousands of pure growths were thus secured. Corn-meal agar was also poured into Petri dishes and allowed to solidify. Then bits of diseased tissue from below the cortex were placed upon its surface. Invariably those bits gave rise to the same fungus secured by the dilution method. The fungus thus secured in pure culture was maintained for several months on various media. Tho the fungus vegetated luxuriantly on various agars it did not bear pycnidia in them, or spores of any kind. The colonies on all media were colorless and with a floccose, aerial mycelium.

Inoculations from these pure cultures were made on apple and other twigs (pear, rose, blackberry, plum, and peach) in test tubes with a few cubic centimeters of water to keep the culture moist. These resulted in rapid growth and the development in the bark, in about three weeks, of very numerous pycnidia of compound, chambered structure, identical with that found in the natural cankers as described above, tho under these conditions there was always an extensive development of aerial mycelium not found under the less humid natural conditions. On all species of

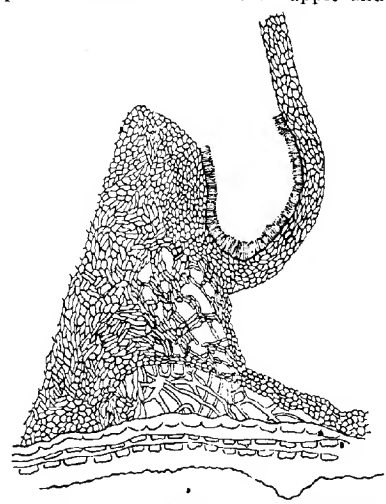

FIG. 14.—DETAIL OF PORTION OF PYCNIDIUM MARKED "A" IN FIG. 10

twigs employed, except box-elder, cherry, and maple, the fungus grew well, penetrating under the cortex thruout the whole length of the twig, some 8 to 10 cm., and breaking out with its erumpent pycnidia over all parts of the twig. On certain twigs, e. g., those of blackberry, tho growth was abundant and rapid, the pycnidia were much smaller than on apple twigs, yet no difference was noticeable in the spores. Careful search was made in all cultures for an ascigerous stage, but none was found.

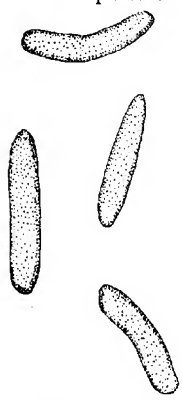

FIG. 15.—SPORES

No attempts to produce the disease on trees in the open were made because it was not thought wise to run any danger of giving it wider introduction in this state. From the laboratory evidence as well as from the statements of Mr. Callender it appears that this canker is one of very rapid development and one that might cause serious loss should it become widespread and suitable conditions for its development obtain.

SIMILAR FUNGI ON ROSACEOUS TWIGS

This fungus evidently belongs to the form genus Cytospora Ehrenb. (Cytispora Fries.) Several Cytosporas have been referred, on more or less conclusive evidence, to the ascigerous genus Valsa Fries. It is therefore of interest in connection with this canker to note other cankers that have been reported upon related hosts, due either to Valsa or to Cytospora.

VALSAS ON ROSACEOUS HOSTS

There are more than 225 species of the genus Valsa proper noted by Saccardo.[8] Lindau,[5] with a broader conception of the genus, says there are about 400 species. The following list, tho not entirely complete, at least contains the names of the most important of these, from the viewpoint of pathology, that occur on Rosaceous hosts. The synonomy and conidial relations, when stated, are as given in the article cited.[1]

1. Valsa ambiens Fries (1:565) (2:120) conidia=Cytispora carphosperma Fries (2:120) (5)=Cytispora leucosperma Fries (25:826)=C. ambiens Fr. (7:2,729). On apples in Europe (8:1,131) (11:278). On most deciduous trees (5)
2. Valsa acclinis Fr. on Pyrus (8:1,130)
3. Valsa amphibola Sacc. on Pyrus (8:22,354)
4. Valsa ceuthosporae Cke. on Prunus (8:1,143)

[1]The first number given in parentheses refers to the Bibliography, as does also any number standing alone in parentheses. Numbers following indicate volume and page.

5. Valsa ceratophora Tul. (5) (8:1,108) on broad-leaved twigs in Europe and North America
6. Valsa cerasi Feltg. on Prunus (8:17,563)
7. Valsa cincta Fries (10) (8:1,143) (5) on Prunus in Sweden, London, Germany, and France=Cytospora rubescens Fr. (33)
8. Valsa coenobitica (de Not) Ces. and de Not (5) on broad-leaved trees in Germany and Italy
9. Valsa clypeata Fuck. on Rubus (5) (8)
10. Valsa coronata (Hoffm.) Fr. on Crataegus (8)=Cytospora
11. Valsa crataegi Allesch. on Crataegus in Europe (5)
12. Valsa cydoniae on Cydonia vulgaris in Portugal (5)
13. Valsa excipienda (5) Karst. on Sorbus (8:1,139) Finland and Lapland
14. Valsa excorians C. and E. on Pyrus (8)
15. Valsa flavovirescens (Hoffm.) Nitz. (5) on various broad-leaved trees in Europe
16. Valsa hoffmanni Nitz. on Crataegus (8:1,118)=Cytospora. On peach, plum, and almond (29:485). On apricot
17. Valsa lauro-cerasi Tul.=Cytospora lauro-cerasi on Prunus (8)
18. Valsa lata (Pers.) Nitz. (5) on various broad-leaved trees in Europe
19. Valsa leucostoma (Pers.) Fries (8:1,139) (10) (22) (2:120) (5) (28) (27:515) (4)=V. personii Nitz. (5)=Cytospora rubescens Fr. (5) (14) (33) (11:278)=C. leucostoma (10) (6:180). On Prunus in Europe (34) and North America (8) (4:264). On pome and stone fruits in Europe, Australia, and America (11:278). On peach, plum, and almond (29). On peach, plum, apricot, and cherry (14). On cherry in America (9:184). On peach (4:264) (15). On cherry (10)

    Valsa leucostoma Fr. var. cincta Rolfs, common on stone and pome fruits everywhere (9:180). On peach (9:300)

    Valsa leucostoma Fr. var. rubescens Rolfs. On apricot and almond (9:157). On plum (9:360)
20. Valsa massariana de Not on Sorbus (8:1,138)=Cytospora
21. Valsa macrostoma Rehm. on Prunus (8:1,145)
22. Valsa mahaleb C. and E. (8:1,137) on Prunus
23. Valsa maura (Fr.) Nitz. (5) on wood of Prunus spinosa in Sweden and Germany
24. Valsa microspora (Crouan) Sacc. on Crataegus (8)
25. Valsa microstoma (P.) Fr.=(Cytospora microstoma) on Prunus (3) (7) (8:8,111)
26. Valsa monadelpha Fr. on Prunus (8:1,128)
27. Valsa opulifolia Pk. on Spirea (8:9,449)
28. Valsa prunicola Pk. on Prunus (8:9,452)
29. Valsa prunastri (Pers.) Fr. on Prunus in Europe and North America (5) (2:111). On plum, apricot, and pear (4:264) (13:218) (6) pycnidia= Cytospora rubescens (2:111) (12:196). Lindau (4:264) says the connection is doubtful. On apple, plum, etc. in England (11:278). On apricot, peach, and plum (26:77)
30. Valsa rhodophila B. and Br. on Rosa (8:1,136)
31. Valsa rubi Fuck. on Rubus (8:1,109)
32. Valsa sorbi (All. and Schw.) Fries (5) on Sorbus in Europe=Cytospora rubescens (12:196)
33. Valsa siberica Thüm. on Cotoneaster (8)
34. Valsa sorbicola Nitz. on Sorbus (8:1,124)
35. Valsa sepincola Fuck. on Rosa and Rubus (8:1,134)
36. Valsa tumidula Cke. and Pk. (5) on Crataegus and Platanus

In the accompanying tabulation are given the Cytosporas recorded as such on Rosaceous hosts; also the Cytospora-like conidial forms of various Valsas on Rosaceae.

CYTOSPORAS AND CYTOSPORA-LIKE FORMS ON ROSACEAE
Arranged in order of minimum spore length (μ)

No.	Name	Saccardo Vol.	Saccardo Page	Spore Length×Breadth	Shape	Locules
1	*C. cerasicola* Sacc.	3	255	3×1	Curved	Many
2	*C. dendritica* Berl. and Vogl.	10	244	3–4×.5	Allantoid	Many
3	*C. asterophora* Sacc.	3	254	3.5–4×1	Allantoid	4–5
4	*V. japonica*	..	...	3.5–15.7×1–2.6	.....	.....
5	*C. rubescens* Fr.	3	253	4	Allantoid	.....
6	*V. ceratophora* Tul.	1	108	4×1	Allantoid	Many
7	*C. candida* Speg.	22	956	4–6×1	Curved	.....
8	*C. microstoma* var. *amelanchieris* Cke.	10	244	5–6	.....	.....
9	*C. leucostoma* (Pers.) Fr. ..	3	254	5–6	.....	.....
10	*C. capitata* Sacc. and Schl...	3	254	5–6	Oblong-botuliform	Sinuous
11	*V. hoffmanni* Nitz.	1	118	5–6×1	Allantoid	.....
12	*V. microstoma* (P.) Fr.	1	111	5–6×1.4	Allantoid	Many
13	*C. rosarum* Grev.	3	253	5–6×1.5	Allantoid	Many
14	*C. carphosperma* Fr.	3	274	5–6.5	Allantoid	.....
15	*V. rhodophila* Berk. and Br.	1	136	5–7×1	Allantoid	Many
16	*V. excipienda* Karst.	1	139	5–8×1	.....	Many
17	*C. niphostoma* Sacc.	11	509	5–8×1–1.5	Allantoid	Many
18	*C. farinosa* Feltg.	18	297	5.5–7×1.5–2	.....	Few
19	*C. cydoniae* Schl.	22	955	6	.....	Many
20	*V. coronata* (Hoffm.) Fr. ..	1	110	6×1	Allantoid	.....
21	*C. clypeata* Sacc.	3	252	6×1	Allantoid	Many
22	*C. ambiens* Sacc.	3	268	6×1	Botuliform	.....
23	*V. sepincola* Fel.	1	134	6×1.5	Curved	Many
24	*V. massarriana* de Not.	1	138	6–7×1	Allantoid	.....
25	*C. microspora* (Cda.) Rabh.	3	253	6–7×1–1.3	.....	Many
26	*C. microstoma* var. *cotoneastri*	10	244	6–7×1.5	.....	.....
27	*C. lauro-cerasi* Fuck. var. *ramulorum* Sacc.	3	276	6–8×1	Botuliform	.....
28	*C. cincta* Sacc.	3	254	6–9×1.5–2	Curved	Few-many
29	*C. cydoniae* B. and K.	18	297	6–9×2	Allantoid	Many
30	*C. anceps* Sacc.	3	255	6–10×1	Allantoid	1–few
31	*C. foliicola* Lib.	3	275	7×1	Botuliform	.....
32	*C. mespili* Sacc.	11	509	7×2	Allantoid	Many
33	*C. prunorum* S. and S.	18	297	7–8×1.5–2	Allantoid	Many
34	*C. crataegicola* P. Brun. ...	14	915	7–8×3	Straight	.....
35	*C. leucosticta* Ell. and Bart.	14	916	7–10×1.5	Curved	Many
36	*C. cincta* Sacc. var. *amygdalina* Karst.	10	245	7–10×2	Curved	Many
37	*C. macularis* Sacc. and Schl.	3	256	8×3	Allantoid	.....

No.	Name	Saccardo Vol.	Saccardo Page	Spore Length×Breadth	Shape	Locules
38	*C. oxycanthae* var. *monogynae*	14	915	8–9×2–2.5	Botuliform	10–12
39	*C. cotoneastri* Thm.	3	256	9–10×2.5	.....	.....
40	*C. phyllogena* P. and S.	3	275	10–12×2.5–3	.....	Many
41	*C. eutypelloides* Sacc.	22	956	11–14×1.5–2	Allantoid	20–30
42	*C. pruni* Ell. and Dear.	11	509	12–16×2.5–3	Fusoid	1–2
43	*C. selenospora* Oud.	16	903	14×2.5	.....	.....
44	*C. acharii* Sacc.	3	267	.....	Curved	1
45	*C. radophila* Sacc.	..	...	.....	.....	.....
46	*C. rhodocarpa* Sacc.	14	915	.....	.....	Many
47	*C. rubi* Schw.	3	252	.....	.....	.....
48	*C. piricola* West.	3	276	.....	.....	.....
49	*C. oxycanthae* Rab.	3	255	.....	.....	Many
50	*C. persicae* Sch.	3	256	.....	.....	.....
51	*C. personata* Fr.	3	267	.....	Curved	Many
52	*C. leucosperma* (Pers.) Fr.	3	268	.....	.....	.....
53	*C. flavo-virens* Sacc.	3	268	.....	Curved	.....
54	*C. floccosa* Wallr.	3	254	.....	.....	.....
55	*C. globifera* Fr.	3	255	.....	.....	.....
56	*C. hendersonii* Berk. and Bron.	3	252	.....	Curved	.....
57	*C. leucophthalma* B. & C.	3	255	Small	Curved	.....

The questions of the identity of the various species of fungi similar to this, and of their parasitism, are interesting and are worthy of consideration. Obviously final classification must rest on rather complete knowledge of both the ascigerous and the conidial stage and of the biologic or host relationships. As to all of these much uncertainty at present exists. The genus Valsa as treated by Lindau[4] contains the subgenera Eutypa, Endoxyla, Cryptosphaeria, Cryptovalsa, Cryptosphaerella, Endoxylina, Leucostoma, Eutypella, Euvalsa, and Valsella, chiefly distinguished from each other in stromatic characters. Saccardo treats of these subgenera as genera. Many suggestions as to the ascigerous connection of conidial forms have been made, often based merely on the association of the two forms on the same twig. Many of these claims are conflicting, assigning several conidial species to the same Valsa, e. g., at least three Cytosporas are given as the conidial form of *V. ambiens*; or several Valsas to the same conidial form, e. g., *C. rubescens* is by various writers connected with at least four separate Valsas. As to the parasitism of these forms there has also been much discussion and divergence of opinion. Many species, probably a large majority of them, are purely saprophytic, growing only on dead twigs; some follow closely on frost injury or injury from other causes, or may be classed as wound parasites. Concerning the particular question of parasitism of Valsa on drupes: Goethe,[30] Labonte,[46] Sorauer,[48, 49] Raschen,[47] and Zapfe,[37] held the

fungus to be secondary, while Frank,[40, 41] Aderhold,[10] Stewart *et al.*,[18] Rolfs,[14, 15, 16] and later several others,[13, 20, 52] have held that it was the cause of the disease, a view that is now definitely established.

The most comprehensive articles bearing on Cytospora and Valsa on drupes are by Aderhold [10] and Rolfs.[16] Aderhold referred the form on drupes to *Valsa leucostoma*, and by extensive cultural and inoculation studies demonstrated its parasitism.

Rolfs studied Valsa on peach, plum, apricot, and cherry, and showed that the forms are interinoculable; but on the basis chiefly of slight variations in spore measurements, tho to some extent on variations in growth on media, he distinguished two varieties, *V. leucostoma* var. *cincta* on cherry and peach, and *V. leucostoma* var. *rubescens* on apricot and plum, a varietal distinction that has been recognized in at least one textbook.[9] That such a varietal segregation should exist is somewhat surprising, especially when the biologic relations claimed are considered, and the question naturally arises as to the validity, for taxonomic purposes, of the characters selected.

While the literature regarding Valsa and Cytospora on drupes is extensive there are but few references to either as causes of disease on cultivated pomes.

Aderhold[10] made inoculations upon apple, but makes no reference in later publications to its natural occurrence upon that host, tho in 1900[15] he recorded it as the cause of cankers on pear in Proskau.

Von der Byl,[53] also Evans,[56] noted *Cytospora leucostoma* as the cause of die-back of apple trees in South Africa; Darnell-Smith and MacKinnon[38] report Valsa and Cytospora on apple in New South Wales; Nicholls[54] reports death of apple trees in Tasmania associated with *Valsa prunastri* and *Valsa ambiens*; and Ideta[23] in his textbook gives *Valsa mali* as the cause of canker on apple twigs. The illustrations given by Darnell-Smith agree closely with the canker under discussion.

Cockayne[35] mentions what is probably a Valsa on apples, pears, and other trees in New Zealand, but with inconclusive evidence as to parasitism and as to the species of fungus involved.

To place clearly before the reader the difficulties of classification and the necessity of taxonomic revision of these fungi the preceding tables and lists are presented. Truly Aderhold was justified in concluding that from the conidial forms alone it is impossible to make a specific determination.

Tho the fungus here discussed agrees well with the Cytospora of *Valsa leucostoma*, it is best to defer final judgment as to its specific name. It is to be noted that many similar fungi described on other hosts may in fact also grow on Rosaceae; also that Cytosporoid fungi belonging to genera of the Valsaceae other than Valsa may cause cankers on these hosts.

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